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Office of Coal & Environmental Systems

Hydrogen Projects

Palladium/Copper Alloy Composite Membranes for High-Temperature Hydrogen Separation

Product Line: Power Systems Advanced Research, University Coal Research Program

Background/Description

For hydrogen from coal gasification to be used economically, processing approaches that produce a high purity gas must be developed. Palladium and its alloys, nickel, platinum and the metals in Groups 3 to 5 of the Periodic Table are all permeable to hydrogen. However, pure Pd-membranes are poisoned by sulfur, and suffer from mechanical problems caused by thermal cycling and hydrogen embrittlement. Recent advances have shown that 25-50 µm thick Pd-Cu foil membranes can overcome the drawbacks of pure Pd membranes. In addition, hydrogen permeable metal membranes made of palladium and its alloys show high hydrogen permeability, chemical compatibility with many hydrocarbon containing gas streams, and infinite hydrogen selectivity.

The Colorado School of Mines (CSM) have developed and demonstrated the stable operation of their Pd membranes at high temperatures for over 50 days. Based on preliminary results, it is expected that thin, 10 µm composite $Pd_{60}Cu_{40}$ films are expected to exhibit a hydrogen flux up to ten times larger than commercial polymer membranes for H_2 separation, and resist poisoning by H_2S and other sulfur compounds typical of coal gas. Similar Pd composite membranes have been operated at temperatures as high as 750°C. The PI has developed a practical electroless plating procedures for fabrication of thin Pd-Cu composite membranes at any scale.

Goal

The goal of this research effort was to optimize the fabrication of sulfur resistant, high flux Pd-Cu composite membranes, characterize these membranes using x-ray diffraction, SEM/EDAX, chemical analysis, x-ray photoelectron spectroscopy, and evaluate the performance of these membranes for hydrogen separation at high temperatures and in the presence of high concentrations (in the 15,000 ppm range) of sulfur containing gases in a laboratory test system.

Summary of Findings

- Fabricated high selectivity PdCu films through electroless plating under an osmotic pressure gradient to deposit $Pd_{60}Cu_{40}$ alloys on tubular porous ceramic and stainless steel supports.

- Conducted permeability tests over 250-650°C to simulate conditions typical of gas being fed to SOFC and MCFC power generation systems.

- Predicted membrane performance under different operating conditions and potential performance improvements through enhancements in membrane properties.

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None

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